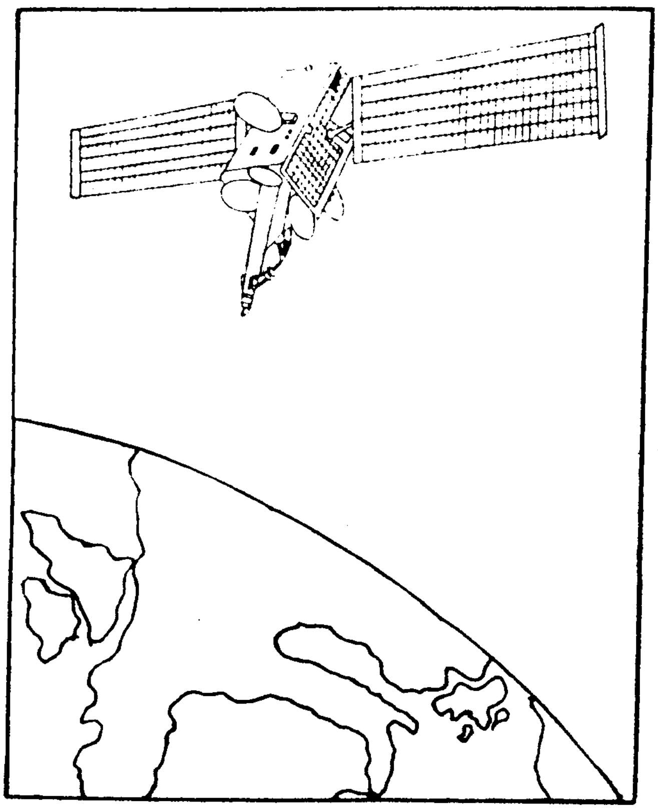
COMMERCIAL POTENTIAL OF EUROPEAN AND JAPANESE SPACE PROGRAMS



TASK V

CONTRACT NASW-4065

FINAL REPORT

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ECOSYSTEMS INTERNATIONAL, INC.

FOREWORD

This report is in fulfillment of Task V of Contract NASW-4065, titled "Space Commercialization". The purpose of Task V is to evaluate, assess quantitatively, present in usable format, the current and expected future competitive status in the commercialization of space of the two pricipal programs competitive with NASA's: the European Space Agency's (ESA) and the program sponsored by the Ministry of International Trade and Industry (MITI) of Japan.

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EXECUTIVE SUMMARY

The **European space program** is comprised of thirteen national programs conducted by thirteen countries, plus the European Space Agency's (ESA) centralized supranational program. The latter is the subject of this report.

The total European expenditures budgeted for space, namely the sum of the national and supranational programs, are about $2 billion in 1987 or approximately 8% of the total US space expenditure, if we include in the latter the programs run by NASA, DOD, NOAA and DOE. ESA's expenditures are about half of the European total, amounting to about $1 billion in 1987, or 4% of the total US space program expenditures, and 12% of NASA's expenditures.

About seventy percent of ESA's program is oriented towards developing commercial uses of space. Thus, despite the relatively small magnitude of ESA's cumulative expenditures with respect to NASA's, the funds that ESA devotes to space commercialization is considerably larger than NASA's.

ESA's definition of what constitutes space commercial programs is broader than NASA's.

Europeans define as commercial, sales by an industry of: i) **off-the-shelf** hardware and software to any space agency, regardless of whether used for R&D or for operational programs; ii) R&D and/or hardware procurements to a European country **other** than the country in which the industry resides, or to any **extra-European** country; iii) **operational** space systems to ESA, other than systems specifically designated as being scientific or otherwise non-commercial.

ESA recognizes three phases in the progress towards commercializing a space system: i) the RDT&E phase--not considered commercial; ii) the **demonstration** phase, where users participate in trying out the system--not considered commercial; iii) the **exploitation** phase, where users utilize a portion of the system's products on a trial basis, for pay. This constitutes the onset of the system's commercial usage. If everything works, the system is eventually turned over to the users.

ESA's commercial space users, frequently designated by Europeans as "private", are not by and large private industries in the US sense. Only about 20% of the European industries sufficiently large to participate meaningfully in space commercial endeavors are truly private concerns. The remainder 80% are in whole or in part owned by their respective governments. Thus they can be induced to some extent to accept government-dictated policies, especially regarding space commercial endeavors.

ESA's commercially-oriented mainliner thrusts are: i) communications, including voice, data, video relay and direct broadcast; ii) remote sensing of the Earth's resources; iii) the Ariane launch vehicle; iv) microgravity experiment carriers; v) microgravity experimentation aimed at generating new industrial products and processes.

In the area of **space communications**, as of mid-1987 , ESA had developed and launched 1 demonstration and 5 partially or wholly commercial satellites. Planned for the near term are another 2 commercial, 1 partially commercial satellites.

In the **remote sensing** field, ESA is developing the ERS-1 demonstration satellite, slated for launch in 1989, and to be followed by one or two more, essentially identical versions but oriented commercially, to provide continuity of service. This is in addition to four meteorological satellites: one mixed demonstration and commercial, three wholly "commercial". ESA's EARTHNET service does and will continue to provide for dissemination of the remotely sensed products.

As regards **launch vehicles**, ESA has developed the Ariane, whose current version, Ariane 4, is now sold commercially as a carrier of satellites into orbit.

ESA's **microgravity** experiment **carrier**, EURECA, proposed to be launched from Shuttle in 1989, to be retrieved six months later, will initially be an experimental system. It is planned to become a commercial endeavor should the experimental phase be commercially successful.

The **microgravity program**, originally under ESA's Scientific Programs Department, has in 1984 been transferred to the Space Transportation Systems Department. Its budget, that used to be included within the science programs, has since 1985 been defined on its own; it increased almost 80% from 1985 to 1986. This is a significant step towards commercialization.

ESA's intent is to convert the microgravity program, as soon as results warrant, from experimental to commercial. A level of funding for microgravity of about $600 million for the four years 1988 through 1992, proposed by the European scientific community, is being debated within ESA's Board of Directors.

For the further future lying between the early nineties and 2000, ESA is proposing to spend about $7 billion for the aggregate of the above commercially-oriented programs, subdivided as follows: 26% for telecommunications, 31% for development of the next generation Ariane 5 launcher, 22% for Earth Observation, 7% for microgravity (possibly as much as 12% if pending recommendations by the scientific community are implemented), and 15% for programs related to participation in the US Space Station.

The basic long-range intent of ESA's program is: i) to attain, by year 2000, **independence** from reliance on the US space program; ii) to **exploit** in the interim NASA's infrastructure, technology and money to learn how to gain independence; iii) to continue fostering the **commerciality** of the space program; iv) to foster **employment** of, and the acquisition of **know-how** by, European engineers and scientists, to eventually enable Europe to compete with the technological leaders, US and Japan.

The **Japanese space program** is conducted by two principal agencies. The National Space Development Agency (NASDA) runs most of the program and has the largest budget; the Institute of Space and Astronautical Sciences (ISAS) runs the space program's scientific missions. For specialized chores, NASDA and ISAS are assisted ad hoc by governmental scientific and engineering organizations reporting to various interested Ministries, e.g., Post and Telecommunications.

The total Japanese space expenditures, including all agencies, are budgeted at about $522 million in 1987. NASDA receives the lion's share, in excess of 90%. The total Japanese space budget is about 6.2% of NASA's, 50% of ESA's.

Both NASDA and ISAS have openly expressed their disinterest in the commercial uses of space. As such, the Ministry of International Trade and Industry (MITI), with a budget of about $8 million in 1987, but with a lot of influence, exerts the only role in spearheading space commercialization.

MITI views space commercialization quite differently from the US and Europe, and in the same way they look at other Japanese industrial endeavors. MITI's common sense thinking is based on the fact that Japan produces less than 10% of the raw materials necessary to sustain its economy. To import these, Japan must export something in exchange: they found the most profitable exports to be finished products characterized by moderately high technology, high quality, and large sustained markets.

To implement this thinking, MITI provides selected industries with seed money in the form of technology contracts, bank guarantees, similar capability-fostering mechanisms—all aimed at eventually generating export sales; or, alternatively, at developing domestic products that minimize the need for imports.

MITI applies the same thinking to space commercialization. Hence MITI is interested in:

- o Space programs that are valuable to the Japanese internal economy to save on imports, e.g., telecommunications to circumvent the need to import communications hardware and know-how

- o Space programs that can assist Japanese industry in obtaining "quid-pro-quos" from other nations, e.g., remote sensing to detect oil fields and trade this knowledge for exploratory concessions

- o Space programs that render Japanese industry proficient at selected technologies that can later be turned into saleable export items, e.g., Synthetic Aperture Radars

National prestige is not very important to MITI, except as it can assist export sales. "Independence" is not an important issue, as it is in Europe.

In line with the above-stated policies, MITI considers the principal areas of space commercialization to be:

-remote sensing of the Earth's Resources
-microgravity

and additional potential areas to be:

-launch vehicles
-telecommunications

In the area of **remote sensing**, the key Japanese program, that MITI had a major role in planning, is the Earth Resources Satellite (ERS-1). In MITI's thinking, this satellite, slated for launch about 1991, will serve to obtain oil exploration concessions in Third World Countries, by trading these against SAR findings.

The Earth Resources Data Analysis Center (ERSDAC) is devoted to investigating promising petroleum and mineral deposits from ERS-1 data and processing and distributing ERS-1 products. ERSDAC's funding derives from the Japanese petroleum industry and from MITI. ERSDAC is equipped with the best image-interpretation technologies now available, and is manned by petroleum and mineral geologists, plus data processing personnel.

To assist its planning in the **microgravity** field, MITI has assembled a cadre of Japanese industry exponents. These have so far identified at least six promising microgravity areas, and are also investigating the desirable characteristics of a microgravity experiment carrier. Advanced plans are being developed to exploit NASA's Space Station for microgravity research, at low cost to Japan.

As regards **launch vehicles,** MITI is currently pondering the economic advisability of entering the world launcher market, especially in view of the already established competition on the part of the US and Europe. We believe that the outlook for Japanese entry is as yet uncertain.

We believe that a similar uncertain outlook holds in space **telecommunications.** In fact, recent MITI analyses have shown Japanese DOMSATS to be not cost effective with respect to investing in advanced terrestrial systems such as fiber optics, new-generation communications processors. MITI has recommended that the government place a moratorium on the launch of further commsats.

In summary, the Japanese space commercialization program, spearheaded by MITI, has so far come up with only one advanced space system, the ERS-1; it is investigating the eventual commerciality of microgravity; has put a brake on communications satellites; and is still pondering whether to enter the launcher market.

As regards intent, national prestige and independence are but minor issues: MITI plans to follow a strictly business, bottom-line oriented, profit route. In line with this policy, MITI will listen to its own industrial advisors as regards commercial potentials of space; but will also follow keenly the outcome of US space commercial programs. In particular, the degree of economic success of the US microgravity program will guide MITI as to whether to "jump in", or engage in a modest program, or abstain altogether.

1.0 INTRODUCTION

Europe's and Japan's are the two space programs that compete with NASA's space commercialization program. The objective of this effort is to evaluate and quantify the extent of the competition, in order to allow NASA management to judge the competition's depth, intent and future growth. The first portion of this report concentrates on the European program. The second portion addresses the Japanese program.

By space commercial programs we mean endeavors aimed at fostering profitable space ventures. Examples of these are: spaceborne remote sensing systems that produce imagery for sale; microgravity platforms that offer on-board facilities for lease; direct broadcast satellites whose air-time is saleable to subscribers. In the U.S., the designation **commercial** connotes space ventures that are financed and operated by **private** concerns—even though their early proof of concept may be initiated and funded by U.S. government agencies.

In Europe's case, the definition of "private" needs to be expanded to include **government-supported** enterprises. This is because of the different socioeconomic infrastructure and political atmosphere prevailing in Europe. In terms of revenue, truly private enterprises in the U.S. sense, comprise only about 20% of the European industries that are sufficiently large to meaningfully address space commercial activities, whether as aerospace contractors or as commercial users. The remainder 80% or so large enterprises are in one way or another ultimately owned and financed by governments, either directly or through intermediary holding companies.

In the space commercial arena, the case of DOMSATS (Domestic Communications Satellites) exemplifies the socioeconomic structure typical of Europe.

In the U.S., DOMSATS are paid for, managed and operated by truly private concerns that compete with each other on the open market. In Europe, the situation is not as clear cut.

For example, one proposal under debate is that European DOMSATS be owned and operated by an inter-European agency, EUTELSAT, that would be owned jointly by the participating governments (EUTELSAT at present is an intergovernmental organization headquartered in Paris). In this proposal, the DOMSAT services would be channeled through the PTT's (Post and Telegraph agencies), that are non-competing, state-owned monopolies (one per country).

Another proposal is that DOMSATS be coordinated only by EUTELSAT, and owned jointly by EUTELSAT and the participating PTT's. Regardless of whichever proposal ultimately wins out, DOMSATS would still, in the final analysis, be owned by the participating European Governments, and would be operated essentially as monopolies.

In net: U.S. DOMSATS must be profitable; European DOMSATS not necessarily so--if they can supply a service considered "socially valuable". However, whether financially or socially profitable, they are still termed by the Europeans as "private".

To further clarify the significance of what Europeans call "private industry", we must remember that during the thirties, numerous European enterprises (industries, banks etc.) were suffering from the great depression. Rather than let important enterprises disappear, Italy first and the other governments later, began purchasing the threatened companies' shares. The industries in difficulty thus received an infusion of needed government cash, in exchange for a portion of their shares: the remainder of the shares were still held by the public at large and traded on the stock markets.

Upon becoming part-owners, governments began installing representatives on the several companie's Board of Directors.

Initially, the fraction of shares purchased by goverments was relatively small, say on the order of 10-20%. As time elapsed, this fraction grew, until at present about 80% of the large industries have turned over all or most of

their entire packet of shares to their respective governments: thus becoming in essence government-owned.

European government-owned industries do however preserve a semblance of "private" behavior, in that they compete with each other, prepare their own profit and loss statements, pay their own taxes. The principal difference with respect to how US industry operates is felt at year's end: if a Government-owned enterprise closes its books "in the red", the government makes up the deficit and the enterprise continues to operate, on the grounds that doing so is " socially valuable" when contrasted with the consequences of letting that industry disappear.

To achieve as much as possible an "apples-to-apples" comparison of commercially-oriented space programs, we have subdivided the European commercial space endeavors in the same categories that are being pursued by the U.S. National Space Program, see Chart 1.

We have segmented the span of our investigation into two successive time frames. The earlier time frame reflects historical data; it begins about 1980 and extends to 1986. The later time frame extends from early 1987 into as far into the future as European plans have been formulated. The reason for choosing these temporal frames is twofold; the historical data provide insight into the growth of each program and furnish a gauge as to the magnitude of its total funding; whereas the future plans supply a calibration of the program planner's intent, hence of the degree of competition that NASA can expect in the future, specifically as regards space commercialization activities.

In comparing the content and value of different national space programs, such as the US and the European program, the question that naturally arises is "what ought to be the yardstick of comparison?" The natural tendency and frequently used procedure, is to compare the respective **budgets** and/or **expenditures** at the ongoing **currency exchange** rates. The result is only grossly indicative, because, whereas budgets and expenditures do constitute a gross yardstick of relative size, currency exchange rates do not truly reflect the relative "purchasing power" of one currency with respect to another.

Moreover, neither budgets nor purchasing powers truly reflect a space program's quality, i.e., cost/effectiveness or commercial price/performance.

To enhance the realism of the comparison, we have explored the relative merits of converting the budgets and expenditures of the European programs into U.S. dollars, using three different conversion rates for each year under consideration: i) the official foreign exchange quotations ; ii) the United Nation's Purchasing Power Parity (PPP) index, and iii) the "Accounting Unit" (AU) conversion rate.

As can be seen from Chart 2, these three conversion factors differ significantly.

The official rates of exchange are generally the least reliable, because they do not reflect the true relative "values" of two currencies—in our case, the dollar versus a given country's monetary unit. This happens because the official exchange rates are set only in part by the purchasing powers extant within each country: to a large degree, the exchange is influenced by differing interest rates between countries, varying investment risk perceptions, other factors that frequently make one currency more sought after than others, regardless of its internal purchasing power within its country of origin.

The PPP index attempts to compute an "ideal" exchange rate, that reflects the "value" of an average "package" of goods and services in each country's internal market.

The Accounting Unit, or AU, is a composite rate used by the European Space Agency (ESA). In concept, the AU is akin to the PPP. The difference is that the PPP applies to **individual countries**, whereas the AU integrates the several purchasing powers of the **group of countries** that contribute to ESA's budget.

Chart 2 illustrates the trends of these three indices (official, PPP and AU) over the last seven years for the U.S. and major European countries engaged in space programs. Note the significant differences, which, in some years, are as high as 50%: compare for example the official and PPP exchange rates for the UK and Italy in 1984.

To further illustrate the difference between purchasing powers and exchange rates, Chart 3 compares typical prices of selected goods and services in the U.S. and Italy, and computes therefrom what the dollar-lira exchange rate **ought to be** in order to purchase equivalent amount of goods in each of the two countries. Remembering that the dollar-lira exchange rate in December 1986 was about $1=Lira 1,350, the significant discrepancy between U.S. and Italian purchasing powers for the same type of goods and/or services is apparent from Chart 3. From data such as these we compute that, in order to purchase, in Italy, in late 1986, at equivalent prices, the same "breadbasket" as is purchased by the average American family in the U.S., the exchange rate ought to be about $1.00=Lira 2,000. This differs from the official exchange rate ($1.00=Lira 1,350 in December, 1986).

Analogous findings apply to European countries other than Italy.

We note that the monetary conversions indicated above still do not reflect the key, bottom-line parameter of interest to policymakers: namely, what is the relative price/performance between competitive space programs (by price/performance we mean the program's "efficiency", or "what the program will accomplish per dollar spent").

Stated in other words: how well can they afford it? This important assessment, however, exceeds the scope of this effort.

For the purposes of this report, the bottom line question is: which currency exchange ought to be used in comparing U.S. space budgets with their European counterparts on a true "purchasing power" basis?

An exhaustive answer to this question requires more in-depth analysis than is possible in this study. We can however make educated conclusions, as follows. Firstly, the official exchange rate, see Chart 2, fluctuates too widely from year to year to be of much use. Secondly, the PPP rate, although stabler than the official exchange rate, suffers in our case from two disadvantages: i) it reflects relative prices for an "average breadbasket" —

e.g., the Consumer Price Index--rather than reflecting the costs of aerospace systems; ii) it applies only to individual countries, not to the aggregate of the European nations participating in European space programs. By contrast, the Accounting Unit (AU) aggregates the various exchange rates of the individual countries, and is therefore far easier to use.

We choose therefore to employ Accounting Units (AU) as expressing the "value" of European space budgets and expenditures, because i) the AU integrates the several national purchasing powers, and ii) it is widely used in the European space arena, thus data expressed in AU's are the most abundantly available.

Budgetary and expenditure data for the several ESA space programs are presented, both in AU's and in dollars, in Section 2.0 that follows.

2.0 STATUS AND PLANS OF SPACE COMMERCIAL PROGRAMS IN EUROPE

2.1 Overview of the European Space Program

Gaining a thorough understanding of Europe's space program, let alone of its commercial aspects, is a little like trying to categorize the activities of our Commodity Future's market. The complications stem from the fact that there are, in Europe, fourteen space programs: thirteen European nations, each have their own space program, and moreover contribute to the supranational program managed by ESA.

Additionally, some programs are bilateral, e.g., Franco-English, others multilateral, e.g., Franco-German-Italian--funded in part by ESA, in part by the participating nations.

Furthermore, the definitions of what constitutes "commercial" programs vary significantly from those employed in the U.S.

The situation resembles a little the scenario that would exist if the States of the Union each had their own space program, in addition to participating in a centralized federal program, with each State operating under different standards, through multiple inter-state compacts, and with differing goals and aspirations.

The budgetary constraints of the present effort require that, instead of attempting to fully unravel the maze, we address Europe's space program in terms of its **aggregated** features, with primary concentration on ESA's program.

Chart 4 offers a calibration of the **relative magnitudes** of the aggregate European and U.S. space efforts. All economic data are in current dollars and current AU's using official conversion rates between the AU and the dollar. See Section 1.0 for the significance of these conversion rates.

The data shown reflect **total** space expenditures. In the U.S. case, these are the sum of civilian (NASA, NOAA and DOE) plus military (U.S. Air Force) program costs; in Europe's case, the costs shown apply to civilian programs only--because there are as yet no European military space programs. Europe's expenditures shown in Chart 4 reflect the sum of the expenditures by ESA and by the several national space programs.

Chart 4 provides an indication of the respective **total committments** to space (civilian plus military) on the part of the U.S. and of Europe. Note that, when viewed in terms of total committment at dollar-AU exchange rates, Europe's space budget as a percentage of the U.S. budget has somewhat decreased from about 16 % in the early eighties to about 9% currently. This is due primarily to the very substantial increase in the US DOD budget, that has risen, in current dollars, to $14.24 Billion in 1986.

We note in passing that the comparison of the respective US and European **total committments to space** is frequently used by ESA in presenting its budgets and expenditures, especially when requesting funds from the contributing European governments.

Aside from its propaganda value ("if we want to catch up, you have to give us more money"), the comparison has intrinsic value for the Europeans, because they feel that the US military program, even though separate from NASA's, produces its own technology spinoffs that sooner or later are introduced in civilian space uses, and eventually lead to commercial spinoffs that are greater than would be the case if military programs did not exist.

Chart 5 compares the relative magnitudes of the total European space program budgets with NASA's budget. Note that the comparison is somewhat slanted in favor of Europe: in other words, the European budget appears proportionately somewhat higher with respect to NASA's. This is because the European Meteorological program budget is included in the European total, whereas NOAA's and DOE's budgets (about $360 in 1986), are not included in NASA's expenditures.

Even taking this bias into account, we note that the total European space expenditures (ESA plus the national programs) have grown substantially at the same pace as NASA's--they are currently about 24% of the NASA expenditures or about $2 billion for 1987. This is particularly impressive because these expenditures represent a significantly greater strain on European resources than NASA's expenditures do on US resources, thus showing an earnest and growing committment to space on the part of the Europeans.

The nations of Western Europe fund two distinct type of Space Programs: i) the centralized program of the European Space Agency (ESA), and ii) the (thirteen) national space programs of the individual countries.

The centralized ESA program is the largest in magnitude of expenditures and the most significant in terms of centralized direction. It is followed in size by France's, next by the Federal Republic of Germany's national programs.

Chart 6 shows the 1986 expenditure distribution between ESA's centralized program and the sum total of the individual national programs. It can be seen that ESA's expenditures account currently (1986) for better than half of the total European space expenditures.

Chart 7 depicts the respective shares of financial committments to space made by the several European nations in 1986. It shows the sum of each countrie's contribution to ESA, plus the outlays for its own national program. We see that the major spenders, in descending order of budget size, are France, the FRG, the UK and Italy: together, these four countries account for about 88% of Europe's total space expenditures.

It is of some interest how the space agency budgets are distributed in terms of allocations.

In ESA's case, about 10% of the budget is allocated to administration and project management, 5 to 7% to intramural R&D, the balance of approximately 80% to industrial contractors.

In the case of the national space programs, industry receives about 60%, internal Administration and Project Management about 15%, scientific institutions, laboratories and universities the balance 25%.

European industry can thus look forward to a total space business of order 70% of the space expenditures (ESA plus national space programs). This is of course in addition to what they sell to space programs in non-European countries. Chart 8 shows the breakdown of ESA's 1986 expenditures, that are the latest available at the time of this writing. Chart 9 shows the 1985 expenditures.

2.2 How does the European Community view the Space Commercial Business

To compare concretely European and U.S. efforts at space commercialization, it is important to set forth a common denominator of significance, to allow performing the intercomparisons to a common "apples to apples" yardstick.

The Europeans admit that current definitions of space commercialization are somewhat incomplete and occasionally rather nebulous. For the moment, however, they accept two groundrules: i) the yardstick of measurement of the level of commercialization is represented by the **revenues** that accrue to **industry** from space-related commercial activities; ii) these revenues are defined as the **total sales** effected by industry in both **direct** and **complementary** commercial markets, where:

- o Direct markets consist of the **production** of commercial space systems or the **supply of commercial space services, e.g.,** communications satellites, ARIANE launch services.

- o Complementary markets are represented by the sale of products and services that are **peripheral** to or derivatives of commercial space programs, e.g., space communications ground terminals, earth mapping and/or meteorological products/services derived from remote sensing satellites, similar.

Not considered **commercial** up to this time (1986) are RDT&E space systems, paid for by ESA or by the National Programs, that are precursors to operational systems. These **non-commercial** systems include the following principal activities:

- ARIANE **launchers** and corresponding launch services funded by ESA for purposes of **RDT&E** and **demonstration** (we discuss the meaning of "demonstration" later in this report). This included Ariane 1 activities up to 1984.

- **Telecommunications** satellites that are **pre-operational** and that are paid for by ESA, see Chart 11. However, sales of R&D and preoperational satellites to non-European governments or to European space agencies other than ESA and other than the National Agency of the country in which the selling industry is located, are considered commercial.

- **Remote sensing** programs that are in the nature of **RDT&E** and **demonstration** programs, e.g., SPOT 1 and SPOT 2, German Metric Camera for SPACELAB, certain R&D platforms to be launched via the U.S. Space Shuttle

- ARGOS activities. This is a **data-relay** device that flies piggyback on NOAA's Tiros satellite. It collects data from sea-going buoys and relays them back to central stations (one in Toulouse, France, the other in Lanham, Maryland) where they are processed and conveyed to users.

- SARGOS activities— SARGOS is a search and rescue system that relays data from vehicles in peril through satellite to ground.

- Use of SPACELAB, and of pre-operational flights of EURECA, a microgravity platform scheduled to fly about 1989.

Note however that the sale of products or services to third parties from these pre-operational systems is accounted for as commercial.

Apart from the above exceptions, the **space commercial market** is defined by the Europeans as comprising:

- **Telecommunication** and **Direct Broadcast** satellites (DBS) that are **operational** and whose services are sold for pay--to the public or to public agencies, through EUTELSAT or through individual country's PTTs

- **Launch Vehicles** that are **operational** and that are commissioned and paid for by any agency, country or private enterprise for the purpose of lofting a **commercial** payload, e.g., a telecommunications or DBS satellite. This is the case of Ariane 2,3,4.

- **Meteorology** and **Earth Observation** satellites commissioned by European non-space governmental agencies or by extra-European customers of all types.

- **Space Service Platforms**, such as the EURECA unmanned microgravity platform once it becomes operational, i.e., after it begins to accept paying customers.

- **Complementary** markets:

  - earth surface communication terminals (ground, ocean, airborne)
  - terrestrial equipments, products and services related to space-based meteorology, earth observation, navigation, etc.

  - RDT&E and operational products and services sold to private or governmental foreign customers, e.g. sale of lasers to NASA for space tracking.

A specific example, drawn from the area of **communications satellites,** will serve to clarify these definitions.

> The space segment of a communications system that is paid for by ESA for **RDT&E** purposes is **not** considered commercial.
>
> A space segment commissioned for **RDT&E** purposes, and paid for by a **non-European** country, or by a European country **other** than the one in which the selling industry resides, **is** considered commercial.
>
> An **operational** communications space segment that is commissioned and paid for by any Agency or Country **is** considered commercial.
>
> **Ground terminal off-the-shelf** equipment sold to ESA or to any other Agency or Country **is** considered commercial. This is similar to our GSA policy.
>
> **Ground terminal developmental** (RDT&E) equipment sold to any Agency or Country other that ESA and/or the Country in which the seller resides, **is** considered commercial.

We note that the European definition of what constitutes space commercialization is somewhat more concrete than official U.S. definitions; it is also considerably broader than current U.S. definitions.

For example, Europeans do not separate clearly "commercialization" from "privatization". Up to now, there has not been in Europe any true privatization in the U.S. sense: namely, the taking over of a public service, formerly performed by government, by a private company for a fee--presumably at less cost than what it costs the government to perform.

Recently, attempts have been made in that direction in some European countries through the formation of "corporations" to manage certain service sectors--for example, the railway establishment in Italy. These "corporations" are of course not true and tried private concerns, but organizations formed "ad hoc", thus burdened by, and forced to retain, existing personnel cadres, and otherwise dependent upon government continuing to supply the needed deficit funds, at the vim of the political establishment.

In the area of space commercialization, the closest "privatistic" organization is ARIANESPACE. A glance at the roster of shareholders shows however that they are represented by Banks and Industries that are in turn owned by their respective governments, in addition to a substantial share owned by Government Agencies.

Thus, the private or privatized ARIANESPACE is simply an elaborate structure that masks its true nature of a government-owned and government-controlled entity.

Because different from the U.S. definition, it is worth clarifying what the Europeans mean by "demonstration".

Most space systems that are ultimately intended to be commercial undergo a phase in which their sevices are "tested" by prospective clients at ESA's expense. This is the case, for example, of new-generation Communications Satellites: certain clients, e.g. the PTT's, are granted selective access to the space system, in order to verify perfomance. Upon successful completion of the demonstration phase, the system is gradually turned over to its ultimate users, for pay. This turn-over connotes the onset of the commercial phase.

The gradual turn-over is often termed by ESA as the "exploitation" phase. As an example, based upon the practice employed for communications satellites, the user organizations pay agred-upon amounts for the use of a stipulated number of satellite channels. The revenue derived from the exploitation activities, together with other analogous revenues, appears in the ESA budget under the heading "Income from Third Parties". An idea of the magnitude of these "commercial" revenues is offered by ESA's 1986 financial statement: approximately 105 MAU, equivalent to $76 million at the 1986 dollar-AU exchange rate or about 8% of total ESA expenditures. These revenues from external sources are used by ESA as part of its expenditures.

2.3 Space Commercial Activities in Europe

2.3.1 Overall

Using the definitions stated in preceding Section 2.2, Chart 10 presents the growth of industrial "space commercial revenues" in Europe. Since this market research was performed in 1985, the figures up to 1985 show historical values; beyond 1985, they represent estimates.

Clearly, the definitions set forth in the previous section imply that a portion of the revenues designated "commercial" is funded from the European space budget--for example, by ESA for off-the-shelf items, or by national space agencies other than the country where the seller resides, for R&D and/or off-the-shelf items. Above and beyond this portion, the balance is represented by sales to European and extra-European governmental non-space agencies or private concerns.

Let us address the ESA space commercial programs that fall within the categorizations shown in Chart 1.

2.3.2 ESA Activities by Program

2.3.2.1 Communications

ESA's role in space telecommunications is to perform the functions of RDT&E,launch, and in-orbit "demonstration" and "exploitation".

The "demonstration" function includes three elements:

Testing the performance of the overall (space and ground) communications system with a view to assess its ultimate "commercial" performance

Gathering data on propagation and other physical parameters

Working with established telecommunications user organizations (either international organizations such as Immarsat: or, the State-owned PTT's) to perform live tests of communications quality, ease of access, etc.

In the latter role, often called "exploitation", the user organizations pay agreed-upon amounts for the use of a stipulated number of satellite channels. These revenues from external sources are "reinvested" by ESA as part of its expenditures. Note that , despite its RDT&E characteristics, all of ESA's space telecommunicatious program is commercially-oriented, in the sense that its intent is to precurse act as precursor for eventual commercial systems.

Chart 11 lists the space telecommunications satellite programs engaged in by ESA since the early eighties. A brief description of these follows.

The **Orbital Test Satellite (OTS)**, built by the European MESH Consortium with British Aerospace as prime contractor, was ESA's first telecommunications satellite. Its purpose was to test the performance of TV, voice and data transmission, in concert with the PTT's of several European Countries. OTS-1 was launched in September 1977 from Cape Canaveral by a Delta booster that exploded. OTS-2, launched in May of 1978 from Cape Canaveral, also by a Delta, was successfully placed in geostationary orbit at longitude 10° East.

The **MARECS** series, built by British Aerospace as prime contractor, provides telephone, telex, facsimile and high speed data (56 kbps) service for maritime use to the international organization INMARSAT.

The initial MARECS-A, launched in December 1981 from Kourou by Ariane, and positioned in geostationary orbit at longitude 26° West, was used for demonstration as well as operationally. MARECS B-1 was lost due to Ariane failure.

MARECS B-2, launched November 1985 by Ariane 3, is located at longitude 177° East. The satellite is also used to relay signals from vessels in difficulty.

The European Communications Satellite family (ECS -1,-2,-3,-4,-5) is intended to become the prototype of the operational European Domsats. Built by British Aerospace as prime contractor, its service covers Europe, the Middle East and North Africa with telephone, TV, data, facsimile and telex transmission, computer links and teleconferencing.

Control of the early ECS's (ECS-1,-2,-3) lies with the state-sponsored European organization EUTELSAT (European Telecommunications Satellite Organization). ECS -1,-2,-3 are not under PTT control because of their experimental nature.

The Earth terminals can be normal gateways as well as small, dedicated terrestrial terminals. Launch is from Kourou through Ariane.

The ultimate intent of the ECS program is commercial: although considerable experimental content was necessarily included in the early versions ECS-1, ECS-2, ECS-3. Future satellites ECS-4 and ECS-5 are expected to be fully commercial; who will own and/or control them will depend on the results of negotiations between Eutelsat and the PTT's of the several interested European Countries.

Olympus, built by British Aerospace and Selenia Spazio as prime contractors, is intended to test advanced telecommunications technology; including:

- o TV broadcast at 12 GHZ
- o Business transmissions including videoconferencing at 12-14 GHZ
- o Videoconferencing, educational programs, data and imagery transmissions at 20-30 GHZ
- o Propagation measurements at 20-30 GHZ.

To be launched in 1988 from Kourou by Ariane 3, and positioned at longitude 19° West, Olympus will, in addition to providing tests and demonstration, also serve to relay telecommunications data on a paying basis.

The Advanced Orbital Test System (AOTS) is planned to be a large project to test and demonstrate further advanced telecommunications technologies, including use of relatively large antenna structures (upwards to 10 meters), high-frequency transmission (20-30 MHZ and higher), point-to-point and gateway transmission, and other technologies and processes currently being defined. Deployment is not foreseen by ESA before 1993.

The Data Relay Satellite (DRS), planned for deployment not before 1994/1995, is proposed as fulfilling a role closely akin to that of NASA's TDRSS. It is currently approved only as a study project.

The **Land Mobile Communications Satellite (LMCS)** is envisioned by ESA as a space system to relay voice and data for mobile communications (mobile to base, mobile to mobile).

The program is closely patterned after NASA's Land Mobile Satellite System (LMSS), pioneered and spearheaded by NASA's Communications Division since about 1976.

The intent of LMCS is to serve as a geosynchronous relay station to connect land-based vehicles (automobiles,trucks,trains etc.) and marine vessels (pleasure and commercial boats).

The geographic area of coverage is envisioned by ESA as embracing all of Western Europe plus the mediterranean coasts of North Africa and the Middle East.

The operating frequency allocation is currently envisioned to lie in the 1,500 megahertz band; number of channels up to about 200.

The principal problems facing the LMCS's current conceptual design are : i) limited market, i.e.,small number of mobile systems present in Europe (this is one reason why ESA projects LMCS's IOC to 2000); ii) the small antenna diameter specified by ESA (about 3 meters). This causes the corresponding footprint to cover substantially all of the geographic area of interest, thus prohibiting frequency reuse, hence limiting the number of effective channels.

For these reasons, the commerciality of the LMCS as presently conceived, is doubtful. We are of the opinion that ESA will reevaluate the program incorporating more commercially-viable specifications, especially if the corresponding US program, currently underway with several applications by private concerns pending before the FCC, should demonstrate commercial value. This is another example where ESA will attempt to exploit the US and NASA experience, at very little R&D cost to the European Community.

2.3.2.2 Space Transportation

The single space transportation program in which ESA has concentrated is the Ariane launcher and related infrastructure. The latter includes the Kourou launch site, mission control facilities located at Darmstad, West Germany, and worldwide mission support facilities. The schedule of Ariane's ESA activities is shown in Chart 12.

The current generation, up to Ariane 4, consists of unmanned operational ELV's whose basic designs are complete.

Chart 12 shows the total end-to-end program costs incurred for the Ariane's RDT&E program (Ariane 1): 1,390 MAU from inception in 1973 to completion in 1984. Since the Ariane 1 program consisted of RDT&E and Demonstrations,it is not classed as commercial by ESA.

Subsequent Ariane generations, beginning with Ariane 2, were and are destined to loft payloads for sale, hence are classed as commercial.

A recent forecast of the commercial potential of Ariane, performed by ESA and ARIANESPACE, is shown in Chart 13. It can be seen that ESA expects Ariane to capture about 35% to 43% of the world's market of commercial satellite launches in the near term. It should be noted however that the market represented by the launch of European satellites is substantially a captive market. This is because of the European policy stating that all member nations of ESA, and ESA itself, must use ARIANE in launching their satellites, unless i) such a launch is not possible due to the special nature of the payload, e.g., EURECA, which must be periodically retrieved in orbit ,hence must be launched by Shuttle; or ii) non-Ariane launchers offer a substantially lower price—currently set at 15% below Ariane's price.

If we subtract the captive European market from the figures shown in Chart 12, Ariane's non-European world market share would be less, but still impressive: 24% in the medium capture hypothesis, 30% in the high or optimistic hypothesis.

A more capable vehicle, the Ariane 5, slated for first launch on or about 1994, is currently in the process of design and limited development. The Ariane 5 will be man-rated, thus capable of lofting manned spacecraft such as the Hermes minishuttle, whose early study phases are currently being funded by several of Europe's National Space Programs, and may be expanded in the future with ESA participation.

Ariane 5 is viewed by the Europeans as a major stepping stone towards the goal of independence from other space programs, notably the US program.

We also see from Chart 12 the significant, by European standards, disbursements effected towards the construction of the two launch sites in French Guyana, Kourou 1 and Kourou 2 (also known as ELA-1 and ELA-2).

The last entry on Chart 12,labeled "Ariane User Support",is particularly significant from the perspective of space commercialization. Its purpose is to assist Ariane commercial users to cope with the complex procedure of accommodating their particular payload to Ariane's launch configuration and launch requirements.

We note that this policy of "free" assistance diverges significantly from NASA's policy with respect to Shuttle, in that Shuttle users currently have to foot the expense of accommodating their payload to Shuttle's configuration and requirements. Commercial US suppliers of ELV services will also be impacted by the existence of this "free" assistance: this is because payload accommodation in U.S. commercial ELV's is borne by the customer, either as a direct expense or whether included in the final price.

At present, the budgeted line item "Ariane User Support" is planned to extend to 1988. All indications are that it will be continued--if not under the ESA aegis, then under the sponsorship of CNES, the French Space Agency, that has already funded a budget line item for Ariane assistance activities.

2.3.2.3 Earth Observation Program

ESA's role in the earth observation program is to spearhead the development of earth-observing space systems, and the utilization of their derivative products. Member nations of ESA are encouraged to spin-off their own earth observation programs: thus far, France has done so with their SPOT system; West Germany with their SPAS-01 pallet that did accommodate within the Shuttle. West Germany's Metric Camera has flown on Shuttle successfully.

As regards the products of remote sensing systems, ESA has set up the EARTHNET organization to sell them commercially. ESA's long-term objective is to attain a sufficiently large consistency of paying "customers" to justify ESA's current developments.

Future Meteorological Space Systems, i.e., the MO series, are defined by ESA as commercial— because their products are expected to be "sold" by ESA to weather organizations of the several European countries.

The sequence and funding of ESA's earth observation programs is shown in Chart 14. A summary description of the several programs follows.

The **European Remote Sensing Satellite (ERS)** program, authorized in 1982, prime contractor Dornier, is intended to provide all-weather capability.

The three active sensors: Synthetic Aperture Radar (SAR), Scatterometer, Altimeter, operate in the microwave range.

The first instrument, a single-frequency Synthetic Aperture Radar (SAR) operating at 6.3 GHz, provides a maximum resolution of 30 x 30 meters over an 80 kilometer wide swath, or lower resolutions over a wider swath (up to 400 kilometers). Revisit interval is 3 days. The SAR can be used as a scatterometer for measuring direction and dimensions of waves. The SAR is being built by Marconi, Dornier and Ericsson.

The second instrument, being built by Dornier and Ericsson, is a scatterometer for measuring direction and speed of surface winds.

The third instrument, by Selenia Spazio, is a radar altimeter operating at 13.7 GHz to measure wave height to a tolerance of 0.5 meters, plus land and ice topography.

The satellite altitude will be measured periodically by a ground-based laser system, with reflector located on the spacecraft.

ERS-1 is planned for launch from Kouron by Ariane in 1989, onto a sun-synchronous, 675 kilometer orbit. ERS-2, planned for launch in 1992, will be essentially identical to ERS-1, and will provide continuity of service to the users.

The **Advanced Land Applications Satellite (ALAS)** is still undergoing definition. Very likely, its mission and sensor complement will reflect NASA's Earth Observation System (EOS) developments. A school of thought in Europe holds that the two programs ought to be merged, depending upon the degree of NASA's "cooperativeness".

In the area of **Meteosats**, ESA launched Meteosat 1 in 1977 and Meteosat 2 in 1981. Both are almost identical to NOAA's GOES.

In 1983, an international organization called EUMETSAT (European Meteorological Satellites) was created, with twelve countries as signatories, for the purpose of establishing, maintaining and operating European operational meteorological satellite systems. ESA's and EUMETSAT's joint plan encompasses three phases:

Launch by Ariane 4 in 1987 of Meteosat P2, essentially another copy of GOES.

Launch, between 1988 and 1990, of three satellites of the MO series, planned for operation through 1994/5.

Planning of an advanced program, called Meteosat 2000, for the post-1995 era.

EARTHNET is the European network for the acquisition, pre-processing, archiving and distribution of remote sensing data, including meteo data. Data is acquired and pre-processed at four ground stations located respectively at Fucino (Italy), Lannion (France), Kiruna (Sweden), and Maspalomas (Canary Islands). The products are sold to interested users, following a pattern that is very similar to that originally established in the US by the EROS Data Center.

2.3.2.4 Microgravity

In its early phases, beginning in the latter part of the 1970's, microgravity was addressed by ESA at the scientific research level. Since

1983, microgravity activities have been classified by ESA as **commercial precursors.**

Subsequent to this reclassification in 1984, microgravity activities have been transferred to, and are currently managed by ESA's Space Transportation Systems department, rather than by its predecessor , the Scientific Programs Department. Correspondingly, beginning 1985, the microgravity program, that used to be included in the science programs, has received its own separate budget.

Early studies by several of ESA's member nations, supplemented by about 8 flights of the Texus ballistic rocket (financed by ESA jointly with West Germany's National Program, and including 35 short-duration experiments) constituted the early program, which had spent about 46 MAU of ESA's funds by 1985.

These activities culminated with the Spacelab flight of November 1983 (whose RDT&E and manufacturing costs are above and beyond the 46 MAU spent for studies and experimentation). As seen by comparing Chart 9 with Chart 8, the funding of the microgravity program has been increased by almost 80% from 1985 to 1986.

The follow-on to Spacelab is the retrievable carrier EURECA, to be flown in Shuttle about 1988, designed to be off-boarded and to be later retrieved by the Orbiter after a lapse of about 6 months. Microgravity experimentation is EURECA'S primary goal. EURECA's first flight, planned for 1988/9, will carry microgravity facilities improved over those flown on Spacelab; it is slated to perform some 29 microgravity experiments.

Primed by MBB/ERNO, EURECA weighs 4,000 kg (8,800 lbs), of which 1,000 kg is represented by the experimental payloads: solar panels provide 5.4 kilowatts of electric power. The schedule and financing for microgravity and EURECA are shown in Chart 15.

ESA's further plans for microgravity development are:

Participation in NASA's Space Station

Deployment and exploitation of the Columbus Space Station Module (mostly to be funded by European National Space programs)

Development of the manned Hermes mini-shuttle (still in the early study phase), to be launched by Ariane 5 about 1996 and that is planned to represent the first major step towards European independence from the US in the space arena; eventually, the development of au all-European small space station, still pretty much in the "talking" stage.

Whereas the microgravity experimentation program, as distinct from the development, manufacturing and launch of EURECA, has thus far been relatively modest (a total of 46 MAU spent through 1985), strong pressures are being exerted on ESA by the scientific user community for increasing the program's scope and funding.

An expenditure level of 200 MAU per year from 1988 through 1992, for a total of 800 MAU,was recommended by the scientific community and is being now debated within ESA's board. This funding would cover studies and experimentation, including experimental equipment and launches.

ESA expects that the microgravity program's ultimate commercial fallout would include three major areas: i) improved industrial materials; ii) improved industrial processes for generating improved materials; iii) improved biological materials and corresponding industrial processes.

2.3.3 Long-range ESA planned activities

The ESA programs shown thus far are approved and substantially firm (except for the supplemental 800 MAU funding for microgravity). For the longer term, encompassing the decade of the nineties, ESA is planning additional programs. Chart 16 depicts ESA's forecasted expenditures for these programs. With respect to Chart 16, we note that:

1) to the forecasted program expenditures of almost 10 Billion MAU ($7.1 Billion of 1986 dollars) must be added the expenditures by the several National Space Programs, that will roughly amount to an equivalent figure: yielding a total European outlay of about 20 Billion MAU, or about $14 Billion (in 1986 dollars).

2) The item "in-orbit infrastructure" consists of that portion of infrastructure that ESA estimates would contribute directly to commercially oriented programs. This includes principally: i) participation in the NASA Space Station activities; ii) Studies on the Hermes minishuttle; iii) Studies on an autonomous European Space Station (as yet only in hte stage of advanced discussion).

2.4 Intent

The growing magnitude of the European space program and the direction of the planned future program, portend a serious committment to space. The currently proposed future space programs show that much of the expected growth will be dedicated to commercial endeavors. This conclusion, based on the bare facts of the budgets, is augmented and made more precise from public statements and provate discussions with exponents of the space program and of European industry.

Following we attempt to distill the sense of the intent of the Europeans in space.

Independence by 2000. The banner word "independence" connotes in the European's mind the elimination of reliance upon foreign space programs, most particularly the US program. It connotes a scenario in which Europe will have substantially the same classes of space capabilities as the US, although on a smaller scale. These capabilities are envisioned by the Europeans as ultimately including:

A self-sufficient launch site

Capability for manned space flight

Capability for deploying their own infrastructure, up to and including a space station fully suitable for space experimentation

Industrial capability of producing their own space vehicles and payloads.

This attitude, that departs in a major way from the intent of a decade ago, has been generated, according to European statements, by "lack of cooperativeness" on the part of NASA. Principal complaints by Europeans are: i) NASA has allegedly barred use of the Delta launch vehicle for European launches in the late sixties and through the seventies--this forced the Europeans to develop Ariane; ii) the Shuttle's delays have allegedly caused delays in deployment of European spacecraft; a frequently adduced example is Olympus. The delays have caused budgetary overruns to ESA and to some of the European national programs; iii) results from Spacelab have been disappointing and late, due to NASA's alleged lateness in delivering data; iv) NASA's policy of free dissemination of remotely sensed data has impeded West Germany's flight of SPAS. "NASA will work with us when it is convenient to them, oppose us otherwise".

In the writer's opinion, while the above allegations (regardless of whether true or false) have contributed to the trend towards independence, a deeper motivation is the European's desire to be "reckoned" as a space power.

Exploit NASA in the interim. The intent is to use NASA's infrastructure (Shuttle, Space Station), technology and money to learn how to gain "independence".

For the period 1987-2000, the plan is to:

Take advantage of Shuttle and Space Station by contributing little moneys and demanding equal benefits.

Capitalize on the experience thus gained at low cost to learn as much as possible towards achieving the goal of independence.

Note in fact from Chart 16 the relatively very low level of expenditure planned for the program of "In-orbit Infrastructure", that in essence means contributions to the Space Station.

Commerciality is the name of the game. The structure of the proposed future ESA programs shows major emphasis on commercial uses of space -- including the infrastructure necessary to insure deployment and exploitation of commercial space systems, i.e., launch vehicles.

Fostering Hi-Tech employment and the acquisition of know-how. In 1986, about 20,000 industrial Aerospace workers were employed throughout Europe thanks to ESA's and the several National Space programs. Additionally, the ESA program employs about 2,000 in-house personnel. These employment levels represent a welcome addition to Europe's traditionally job-hungry technical constituency. Additionally, the intent of ESA planners is to upgrade the technological level of European engineers, to enable them to eventually develop the technology needed to compete with the more advanced nations, e.g. US and Japan.

CHART 1
CATEGORIZATION OF POTENTIAL COMMERCIAL VENTURES AND PROGRAMS

SECTOR — **AREA**

- INFORMATION SYSTEMS/SERVICES
  - COMMUNICATION
    - TWO WAY
    - ONE WAY (BROADCAST)
  - NAVIGATION/GUIDANCE
  - REMOTE SENSING OF THE EARTH
    - RESOURCES
    - ATMOSPHERE
  - DIGITAL COMMUNICATION SYSTEM
- TRANSPORTATION SYSTEMS
  - OPERATIONAL
    - SHUTTLE
    - ELVs
    - OTVs
  - EVOLVING
    - LOW COST LAUNCHERS
    - OTVs
    - OMVs
- SUPPORT SERVICES
  - GROUND SERVICES
  - LAUNCH SERVICES
  - MISSION SERVICES
  - ON-BOARD SERVICES
  - SPACE PLATFORM SERVICES
- TECHNOLOGIES
  - MICROGRAVITY PROCESSES/PRODUCTS/SERVICES
  - LARGE SPACE STRUCTURES
  - SCIENTIFIC MARKETS

CHART 2

RATES OF EXCHANGE BETWEEN U.S. AND MAJOR EUROPEAN COUNTRIES

VALUE OF $1.00 IN TERMS OF UNITS OF NATIONAL CURRENCY

AND OF ESA ACCOUNTING UNITS

	FRANCE		FRG		UK		ITALY		ESA
	FRANCS		MARKS		POUNDS		LIRAS		
YEAR	O	PPP	O	PPP	O	PPP	O	PPP	AU
1980	4.23	5.24	1.82	2.37	0.430	0.487	856	759	0.75
1981	5.44	5.39	2.26	2.27	0.498	0.499	1,137	825	0.70
1982	6.57	5.67	2.43	2.21	0.572	0.502	1,353	909	0.93
1983	7.62	5.94	2.55	2.18	0.660	0.505	1,519	1,001	1.02
1984	8.74	6.16	2.85	2.15	0.752	0.509	1,757	1,070	1.12
1985	8.98	—	2.94	—	0.779	—	1,909	—	1.37
1986	6.05	—	1.82	—	0.654	—	1,300	—	1.37

Notes:

O = Official Rate of Exchange, average for the year

PPP = Purchasing Power Parity Index

AU = Accounting Unit, average for the year

— = Not yet officially available

Source: For official exchange rates, Statistical Abstract of the United States, U.S. Bureau of the Census.

For PPP rates, OECD, Dept. of Economics and Statistics, National Accounts, volume I ,1960-1985.

CHART 3
TYPICAL PRICES FOR EQUIVALENT GOODS AND SERVICES, US AND ITALY

DECEMBER 1986

ITEM	U.S. PRICE DOLLARS	ITALIAN PRICE LIRA	PURCHASING POWER OF DOLLAR IN LIRE (1)
Average Highway Toll, Per Mile	0.021	113	5,381
Household Electricity, Per KWH (1)	.06	260	4,330
Overseas Call U.S.-Italy and vice-versa, per Minute, Off Hours	0.61	2,800	4,590
Gasoline, Regular, per Gallon	0.95	5,300	5,580
Car Radio Telephone, Basic Service, per Month	11.00	100,000	9,090
Airfare, Round Trip, Tourist Class, 1,000 miles each way	400	1,200,000	3,000
Round Steak, US Choice, per Lb.	2.20	10,000	4,550
Spaghetti, Family Quality, Per Lb.	0.50	850	1,700
Beer, 12 oz., at Medium Quality Bar	1.25	3,000	2,400

(1) This column shows what the dollar-lira rate of exchange ought to be in order to purchase, in Italy, the good or service called out in the first column.

(2) Computed for an average U.S. household, consuming yearly 9,000 KWH, with 150 Amp service.

CHART 4

COMPARISON BETWEEN TOTAL U.S. AND TOTAL EUROPEAN SPACE EXPENDITURES

CURRENT DOLLARS AND CURRENT AU'S

	TOTAL U.S. (1)	TOTAL EUROPE (2)		
YEAR	CIVIL & MILITARY	AT EXCHANGE RATES (3)		IN AU'S
	$ MILLION	$ MILLION	%(4)	AU MILLION (MAU)
1980	7,668	1,267	16.5	947
1981	9,165	1,537	16.8	1,080
1982	11,860	1,402	11.8	1,315
1983	15,321	1,396	9.1	1,427
1984	17,060	1,516	9.1	1,699
1985	20,368	1,304	6.4	1,779
1986	22,091	1,882	8.5	2,579
1987	23,550	2,021	8.6	2,769

Notes:

(1) "Total U.S." includes civilian (NASA, NOAA, DOE) and USAF space programs.
(2) "Total Europe" includes the sum of ESA's and of all national space program expenditures.
(3) Dollar-to-AU equivalent rates of exchange for each year shown, see Chart 2.
(4) Total European Program Expenditures, as a percent of total US space expenditures.

The figures for 1987 are budgeted expenditures

Source: Official US and ESA data.

CHART 5

COMPARISON BETWEEN NASA'S EXPENDITURES AND
TOTAL EUROPEAN SPACE EXPENDITURES
CURRENT DOLLARS AND CURRENT AU'S

YEAR	NASA	TOTAL EUROPE (1) AT EXCHANGE RATES (2)		TOTAL EUROPE (1) IN AU'S
	$ MILLION	$ MILLION	%(3)	AU MILLION (MAU)
1980	4,340	1,267	29.2	947
1981	4,877	1,537	31.5	1,080
1982	5,453	1,402	25.7	1,315
1983	6,146	1,396	22.7	1,427
1984	6,385	1,516	23.7	1,699
1985	7,500	1,304	17.4	1,779
1986	7,764	1,882	24.2	2,579
1987	8,400	2,021	24.1	2,769

Notes:
(1) "Total Europe" includes the sum of ESA's and of all national space program expenditures.
(2) Dollar equivalent rates of AU for each year, see Table 1-1.
(3) Total European Program Expenditures as a percent of NASA's expenditures.

The figures for 1987 are budgeted expenditures.

Sources: Official US and ESA data.

CHART 6

PERCENTAGE DISTRIBUTION OF SPACE BUDGETS IN EUROPE, 1986

ESA PROGRAM	53%
ALL NATIONAL PROGRAMS	47%
TOTAL	**100**

Source: Computed from European Space Directory, 1986, Eurospace, Paris,France

CHART 7

RELATIVE WEIGHT OF EXPENDITURES BY EUROPEAN COUNTRIES, IN PERCENT OF TOTAL EUROPEAN SPACE EXPENDITURES, 1986 (ESA PLUS NATIONAL SPACE PROGRAMS)

COUNTRY	PERCENT EXPENDITURE (2)
France	35
FRG	23
UK	17
Italy	13
The Netherlands	2
Belgium	2
All Others (1)	8
TOTAL	**100**

(1) "All Others" includes: Denmark, Spain, Sweden, Switzerland, Ireland, Norway, Austria.
(2) Numbers are rounded to nearest integer.

Source: Computed from European Space Directory, 1986, Eurospace, Paris, France.

CHART 8
THE 1986 ESA EXPENDITURE ALLOCATIONS

ITEM	PERCENT	MAU
ADMINISTRATION	8.4%	115
SCIENCE	11.2%	153
SPACE STATION/**PLATFORMS**	13.5%	185
SPACE TRANSPORTATION	27.6%	377
EARTH OBSERVATION	11.2%	153
TELECOMMUNICATIONS	24.9%	340
MICROGRAVITY	3.2%	44
	100.0%	1,367

TOTAL EXPENDITURES: 1,367 MAU = $ 998 Million 1986

Items listed in **BOLD TYPE** are those oriented towards space commercialization.

Source: computed from "Forward to the Future" by ESA, Synelog, Paris, France

CHART 9

THE 1985 ESA EXPENDITURE ALLOCATION

ITEM	PERCENT
ADMINISTRATION	10.3%
SCIENCE	15 %
SPACE STATION/**PLATFORMS**	8.8%
SPACE TRANSPORTATION	30.2%
EARTH OBSERVATION	15.1%
TELECOMMUNICATIONS	18.8%
MICROGRAVITY	1.8%
	100 %

TOTAL EXPENDITURES: 923.8 MAU = $674 MILLION 1986 DOLLARS

Items listed in **BOLD TYPE** are those oriented towards space commercialization

Source: ESA Annual Report 1985

CHART 10

GROWTH AND FORECAST OF EUROPEAN SPACE COMMERCIAL REVENUES

YEAR	CURRENT (1) DOLLARS MILLION AT DOLLAR-AU CURRENT MAU		EXCHANGE RATE
1980	51		68
1981	64		91
1982	139		148
1983	252	ACTUALS	246
1984	411		367
1985	647		474
1986	775		566
1987	882	ESTIMATES	644
1988	913		666

(1) "Current" means dollars taken at their value in the year shown in the first column. Also known as "then dollars".

Source: Market research compiled by ITALSPAZIO, Rome , Italy

CHART 11

ESA'S COMMERCIALLY-ORIENTED TELECOMMUNICATIONS PROGRAM

D= DEMO; C= COMMERCIAL

SPACECRAFT	CATEGORY	IOC	LIFE END	COST TO COMPLETION (MAU) (1)
OTS-2	D	78	85	—
MARECS-A	D/C	81	90	125
ECS-1	D/C	83	90	—
MARECS B-2	C	84	93	132
ECS-2	D/C	84	91	—
ECS-3	D/C	85	92	—
OLYMPUS	D/C	87	92	615
ECS-4	C	88	95	221
ECS-5	C	89	96	
AOTS	D	93	99	—
DRS	D	95	00	—
LMCS	D/C	00	05	—

(1) Total end-to-end program costs

-- = Not applicable or not available

Sources: ESA annual reports, 1982, 83, 84, 85, 86.

The Encyclopedia of Space Satellites, by Giovanni Caprara, Distributed by Crown Publishers, Inc.
The Future of Satellite Communications in Europe, by Andrea Caruso, Director General of Eutelsat.

CHART 12
ESA'S COMMERCIALLY-ORIENTED SPACE TRANSPORTATION PROGRAM

D= DEMO; C= COMMERCIAL

PROGRAM ELEMENT	CATEGORY	IOC	LIFE END	COST-TO-COMPLETION MAU
ARIANE 1 RDT&E	D	73	78	962
ARIANE 1 DEMONSTRATION	D	79	84	427
ARIANE 2-3	C	84	(1)	142
ARIANE 4	C	86	(2)	417
ARIANE 5	C	94	(3)	
KOUROU 1 CONSTRUCTION	D/C	73	84	127
KOUROU 2 CONSTRUCTION	C	86	(3)	154
ARIANE USER SUPPORT	C	81	88	85

(1) Will continue as the market requires- Final phaseout probably 1990-91

(2) As above for (1), but final phaseout not foreseeable at this time

(3) As above for (2)

Sources: ESA Annual Reports, 1982, 83, 84, 85, 86.

The Encyclopedia of Space Satellites, by Giovanni Caprara, Distributed by Crown Publishers Inc.

CHART 13

ESA AND ARIANESPACE PERCEPTION
OF ARIANE'S SATELLITE LAUNCH
MARKET FOR THE 1987-1991 PERIOD

GEOGRAPHIC/ POLITICAL AREA	ADDRESSABLE MARKET NO. OF SATELLITES	CAPTURABLE MARKET NO. OF SATELLITES		SHARE OF MARKET PENETRATION	
		Medium	High	Medium	High
EUROPE	34	30	34	88%	100%
U.S.A.	42	4	6	9.5%	14%
INTERNATIONAL	18	4	8	6%	33%
DEVELOPED COUNTRIES	24	6	8	6%	25%
DEVELOPING COUNTRIES	25	6	24	10%	40%
TOTALS	**143**	**50**	**80**	**62**	**56%**

Source: Market Survey by ITALSPAZIO, Rome, Italy.

CHART 14

ESA'S COMMERCIALLY-ORIENTED EARTH OBSERVATION PROGRAM

D = DEMO ; C = COMMERCIAL

SPACECRAFT	CATEGORY	IOC	LIFE END	COST TO COMPLETION (MAU)
ERS-1	D	89	92	584
ERS-2	D/C	92	96	630
ALAS	D/C	95	98	650
METEO P2	D/C	87	91	145
MO-1	C	88	92	
MO-2	C	89	93	425
MO-3	C	90	95	
EARTHNET	C	80	--	

--- Not applicable

Source: ESA Annual Reports 1982, 83, 84, 85, 86

CHART 15

ESA'S COMMERCIALLY-ORIENTED SPACE PLATFORM/MICROGRAVITY PROGRAM

D= DEMONSTRATION   C= COMMERCIAL

PROGRAM ELEMENT	CATEGORY	IOC	COST-TO COMPLETION LIFE END	MAU
EURECA SPACECRAFT (1)	D/C	89	93	259
EARLY MICROGRAVITY PROGRAM (2)	D	76	—	46 (3)

— = Unforeseeable at this time

(1) Primarily a Microgravity experiments carrier

(2) Microgravity experimentation only, as distinct from space flight hardware costs.

(3) This was cost from inception through 1985. Program is continuing at 40 to 50 MAU/year. A funding level of 200 MAU/year, total 800 MAU from 1988 through 1992, to including studies and space flight hardware, was recommended by the European scientific community. This is currently under debate within ESA.

Source: ESA Annual Reports 1982, 83, 84, 85, 86.

Private Communications.

CHART 16

ESA'S COMMERCIALLY-ORIENTED APPLICATION OBJECTIVES

PROPOSED BUDGETS FOR THE LATE '80 - '90 ERA

MAJOR PROGRAM ELEMENT	AVERAGE BUDGET,(1) TIME HORIZON	TOTAL EXPENDITURE OF PROGRAM MAU/YR	MAU	$ 1986 M
LAUNCHERS	87-97	300	3,000	2,190
COMMUNICATIONS	87-99	210	2,520	1,840
IN-ORBIT INFRASTRUCTURE	89-94	300	1,500	1,095
MICROGRAVITY (2)	87-95	80	640	467
EARTH OBSERVATION	87-97	210	2,100	1,533
TOTALS		1,100	9,760	7,125

(1) Averages the (smaller) expenditures of study and development phases with the (larger) outlays of manufacturing and deployment phases.

(2) Includes hardware and experimentation. 1985 request by Scientific Community is for an increase to 200 MAU/year: This is not yet approved.

Source: Assembled from various ESA publications and private communications.

3.0 STATUS AND PLANS OF SPACE COMMERCIAL PROGRAMS IN JAPAN

3.1 Introduction

We have seen in preceding Section 1.0 that comparisons between the expenditures of space programs mounted by different nations need to be effected with caution in order to achieve a truly representative meaning. Similarly to what we presented in the case of Europe, Chart 17 shows the historical rates of exchange, both official and PPP, between the dollar and the Japanese yen. Analogously to what we observed for the case of Europe, we note the high degree of fluctuation in the dollar-yen exchange rate. The Japanese space budgets are quoted in Japanese yen; the official value of the yen varies with respect to the dollar; thus the meaning of Japanese space expenditures, if converted directly into dollars, would be significantly distorted.

The PPP would provide a better yardstick, except that it is based upon a comparison of Consumer Price Indices (CPI's), rather than on Aerospace Price Indices. This would still induce some distortions.

What is then a proper method of conversion? Fortunately, ESA provides this for us, because they do convert the Japanese space expenditures into AU's, and they do publish the corresponding data. Thus we can use the expenditure data given in AU's and convert the AU back into dollars using the AU-to-dollar exchange rates shown in Chart 2.

3.2 Overview of the Japanese Space Program

Similarly to what happens in the US and Europe, Japan's space program is conducted by more than one government Agency.

However, whereas the official roles and missions of the several Japanese Space Agencies are reasonably clearly defined, their interrelationships are quite complex: moreover the interrelationships are not always fixed, but are apt to shift from space program to space program, and to vary with time.

Further, non-space agencies are asked to participate in certain designated programs side by side with the officially chartered space agencies, whenever their expertize is thought by the supervisory organizations to be particularly useful. This adds another layer of complexity to the overall space program's organization.

Another complicating feature peculiar to the Japanese Space program is that the reporting structure of the Space Agencies is replete with "dotted lines". The agencies receive programmatic and technical inputs from various Ministries, Commissions, Academic Bodies--and, since about 1983,they also receive inputs from especially-formed Industry Associations.

As a rule these inputs are generally taken quite seriously by the recipient agencies: their space programs are shaped accordingly.

While all this may appear somewhat confusing to the American mind, accustomed to well-defined assignments and responsibilities, it is consonant with the Japanese "modus operandi" of management by consensus: listen to everybody, make every group participate in decisions, take recommendations seriously. As such, the established Space Agencie's charters are quite elastic and should be interpreted with a good dose of flexibility.

The Government Agencies that are the principal official players in the Japanese Space Program are:

o The **National Space Development Agency (NASDA)**. Similarly to NASA, NASDA reports directly to the Cabinet and performs its own planning: but receives strong inputs from other executive and advisory bodies.

  Principal among these are:

  The Science and Technology Agency (STA).

The Ministry of Transport (MT), in the area of launch system development.

The Ministry of Post and Telecommunications (MPT) in the field of communications and broadcast space systems.

The Ministry of International Trade and Industry (MITI).

NASDA enjoys by far the largest budget among Japanese Space Agencies. Its stated charter is the research, development, deployment and mission control of all classes of space systems, to except for certain designated scientific missions.

The National Aerospace Laboratory (NAL) assists NASDA on request: as an example, they recently provided technical expertize in developing LOX systems for launch vehicles.

- The **Institute of Space and Astronautical Sciences (ISAS)**. ISAS was founded in 1970 as part of the University of Tokyo under an acronym that meant originally "Institute of Space and Aeronautical Science".

Re-organized under the current name (with the same acronym) in 1981, ISAS is an agency of the Ministry of Science,Education and Culture. Its charter is dedicated to space science.

ISAS's budget oscillates as a function of the programs undertaken; it did reach a peak of about $50 million in 1978, and reached a low of about $7-$8 million in 1986.

ISAS' budget is occasionally augmented by contributions from other agencies, either in funds or in the form of personnel loans.

ISAS' primary purpose is to achieve a consistent space science effort, protected from the disruption potentially caused by other high-risk space endeavors.

ISAS develops its own small launchers and operates its own launch center at Kagoshima.

ISAS is charged occasionally to coordinate scientific endeavors with other Space Agencies and with industries interested in space commercialization.

In this connection, ISAS has now the role of coordinating a 13-industry team, in which MITI is also represented, forming a body called the "Institute for an Unmanned Space Experiments Platform"—a proposed carrier for microgravity experiments.

- The **Ministry of International Trade and Industry (MITI).** Most of MITI's official charter is to foster the health and competitiveness of Japanese industry, including of course the Aerospace industry.

  As explained in more detail later in this report , MITI's important role is to plan which industrial sectors ought to be "pushed" for best results to the Japanese economy. As such, MITI, while not directly operating in space, is the principal force to be reckoned with as regards intent and overall thrust in the commercialization of space.

  Other organizations that play a significant role in shaping the Japanese space program are:

- The **Space Activities Commission (SAC).** Not a line organization, but reporting directly to the Cabinet, SAC is the core organization that plans and influences the direction of Japan's space program. Its job is to "guess right" as to what other nations will be doing in space, and what Japan ought to do to keep up. SAC is the Agency with the strongest say in recommending space budgets to the Cabinet.

As regards the commercial and/or economic aspects of the Japanese space program, SAC receives strong inputs from MITI.

- o The **Science and Technology Agency (STA)** is approximately analogous to our National Academy of Sciences and National Academy of Engineering combined, but with appreciably stronger voice. Its principal job is to direct the efforts of ISAS: it also has a voice in the applications aspects of the space programs.

- o The **National Aerospace Laboratory (NAL)**, the prime Japanese aeronautical agency, is brought to bear onto specialized aspects of the space program, such as development of LOX systems and studies of aerodynamic reentry (NAL is currently testing models of a minishuttle for possible development of a manned capability).

- o The **Electrotechnical Laboratory (ETL)**, an organ of MITI, is brought to bear on particular aspects of the space program: principally on the design of communications satellites and the evaluation of their performance.
- o The **Radio Research Laboratory**, an organ of the Ministry of Post and Telecommunications, participates in the design and test of communication satellites.

- o **Industrial organizations.** Since about 1982-83, Japanese private industry has become deeply involved in the long range planning of the space program. This they accomplish by forming appropriate organizations, preeminent among which are:

    -The **Institute for an Unmanned Space Experiments Platform.** Created under the auspices of ISIS and MITI, its purpose is to

-study and plan an industrial space platform to perform microgravity experimentation. Membership embraces 13 companies

-The **Japanese Federation of Economic Organizations,** under the auspices of MITI, has the objective of stimulating Japanese industrial awareness of the space program and of its market opportunities. Membership is 94 companies.

-The **Society of Japanese Aerospace Companies, Inc.,** under MITI's and NASDA's auspices, with 142 member companies, is concerned with investigating ways and means whereby Japan can use space technology to develop future, long-term international markets.

-The **JAPEX** consortium, under MITI's auspices, is formed by the Japanese oil exploration enterprises. Its current interest in space is to investigate the use of remotely sensed data to improve the probability of success in the search for petroleum deposits world-wide, with emphasis on Third World Countries, especially those sited geographically within the Pacific Basin.

Superficially, these industrial organizations appear to be counterparts of our own industrial organizations, such as the Aerospace Industry Association (AIA). In practice, their role in shaping the future orientation of the Japanese Space program is considerably more influential.

Similarly to what we presented for the European Space program, we compare in Chart 18 the relative magnitudes of the total Japanese space program (sum of the expenditures by all Japanese agencies) and the overall US program (civilian and military).

We note that the total Japanese program amounts now to a little over 2% of the total (civil plus military) US program.

Since there is no military space program in Japan, a more germane comparison can be had from Chart 19, that compares the Japanese space expenditures with those of NASA and ESA. It can be seen that the total (all agencies) Japanese space expenditures amount now to approximately 6% of NASA's, 50% of ESA's expenditures.

The relatively limited magnitude of their space budget has forced the Japanese to be quite selective in their choice of which space programs to pursue. This may represent a strength rather than a weakness, because it has forced the Japanese to think through a rather meticulous planning process, that has fostered a steadily expanding space program with but little waste.

The breakdown of NASDA's 1986 expenditures is shown in Chart 20.

3.3 How do the Japanese view Space Commercialization

Space commercialization is viewed differently in Japan than in the US or in Europe. To understand the reasons for the Japanese outlook, it is important to briefly review the basic concepts and strategies that underlie Japan's overall economic-industrial planning. At the governmental level, this is primarily the responsibility of MITI.

MITI's basic thinking is quite common sense. It can be summarized as follows:

- o Japan produces **less than 10%** of the raw materials necessary to sustain a modern developed economy.

- o As such, Japan **must import** these raw materials. The alternative is non-survival—or at least, non-survival as a modern society.

- o For the same reason, Japan **must limit the imports** of finished products, and develop as much as possible a self-sufficient internal economy.

- To pay for the needed imports, Japan **must export** something in exchange. The only practical export, in sufficient volume to cope with the demands of Japan's internal market, consists of **finished products.**

- The imperative is to export products that make money and that can be sold **quickly and continuously** year after year. The choice of exportable finished products is not overly important: anything that sells rapidly and continuously in the world market will do.

- The choice of what can best sell is performed by meticulous research of the markets of foreign countries, particularly the US--that represents the largest world buyer.

- It has turned out thus far that the most effective products to attain the desired end goal of "sales at all costs" have been items such as home appliances, automobiles, electronic entertainment devices, and in general the host of products with which we are all familiar. The provision of product "quality" is considered by the Japanese to be no more than a sales tool : had the US and World markets demanded low quality at very low price, the Japanese would have tailored their products accordingly.

- In this context, the achievement of "national prestige" is a **secondary objective.** So is the attainment of "high-tech" capability per se. "High-tech" is only important if it contributes to export sales. In fact, excessive use of high-tech could be a deterrent in products destined for export, because of cost and maintenance problems. MITI's policy is "just enough hi-tech to sell the product".

We note in passing that the pursuit of the single-minded policy of "export at all costs" has left the Japanese behind in several fields that require time for their development: large aircraft, aircraft engines, sophisticated space systems, etc. The Japanese are well aware of this fact, but do not seem to be overly concerned about it.

To implement the policy direction consistent with MITI's thinking, a capable and responsive industry is needed.

MITI thus plans which industries need particular strenghtening, and initiates actions accordingly. These actions take the form of government contracts to "seed" industrial capabilities, bank guarantees to industries that develop preferred products on their own, similar.

It is important to note that Japanese industry is predominantly private: it resembles the structure of US industry far more than European industry, which is predominantly government-owned. In Japan, the Government, through MITI, engages in an "enlightened" policy of stimulation of the key industries that are best suited to achieve the desired end-result of significant export sales.

Turning now to space commercialization, **MITI** is and will probably continue to be the **driving force** in this area.

As a matter of fact, both ISIS and NASDA have repeatedly, officially stated that space commercialization does not lie within their charter nor that it is a particularly important goal, at least from their standpoint.

We note however that these statements ought to be accepted with a grain of salt. This is because, due to the interrelationships that exist among Japanese government agencies and industry, MITI can exert a variety of overt or subtle influences on the space program. For example, MITI can influence the design of particular space systems so as to utilize or replace hardware, software and techniques already developed by NASDA; it can influence other Government organizations to assist chartered Space Agencies in novel developments requiring special expertize; it can exert leadership on industry groups interested in space, that in turn can influence certain policies of NASDA and even of ISIS; it can provide strong inputs to STA that in turn can reflect upon specific NASDA programs and policies.

MITI's philosophy in the area of space commercialization can be summarized as follows. MITI is interested in:

- o Space programs that are expected to be of direct **value** to the Japanese **internal economy** in order to save on imports, e.g., remote sensing that might allow increasing the fish catch—very important to Japan's internal economy; or telecommunications that would circumvent the need to import communications hardware and know-how.

- o Space programs that can **assist** Japanese industry in obtaining appropriate **"quid-pro-quos"** from other nations, in particular the developing nations of Asia and the Pacific basin. We will discuss this more exhaustively when we address the ERS-1 remote sensing program.

- o Space programs that serve to **strengthen** Japanese industry in becoming proficient at **selected technologies** that can later be turned into saleable export items. Examples are TWT's for Communications Satellites, Optical Sensors, Synthetic Aperture Radars. We will discuss these later in this report.

National prestige is not very important to MITI, except in cases where it is deemed to be significant as a tool to foster export sales. As such, "independence" is not an important issue, as it is in Europe.

In this respect, MITI's attitude is that if the US wishes to reap world prestige from its Space Station and will foot most of the bill, allowing Japan to use it for what it is worth, so much the better. All MITI wants to do is to use it for its own commercial purposes.

It ought to be noted however that this attitude has changed somewhat in the recent past, so that the national prestige component has acquired a somewhat larger degree of importance—although still quite small with respect to the commercial objectives. Note also that MITI policies do not preclude a given commercially-oriented space program from also providing information of scientific value: the latter constitutes good material for international symposia, keeping Japan's name in front of the international community, thus hopefully helping to achieve more sales.

A major weakness of MITI's in the commercial space areana is the dearth of a good market research: thus decisions are reached to a large extent based not so much on hard numbers as on the US example, and by following the US lead. As a matter of fact, all Japanese space programs, commercial or otherwise, are modeled upon what the US has accomplished in the past and is attempting to accomplish now.

3.4 Commercially-oriented Space Activities in Japan

MITI considers the principal areas of space commercialization, or that are oriented towards space commercialization,to be the following:

- o Remote Sensing of the Earth's resources
- o Microgravity

Areas that are candidate for eventual commercialization, should MITI so decide, are:

- o Launch Systems
- o Space Communications

Let us next address the highlights of these areas.

3.4.1 Remote sensing of the Earth's resources

Thus far, three commercially-oriented space programs have been initiated in Japan: the MOS (Marine Observation Satellite); the ERS-1, also called the

JERS-1 (Japan Earth Resources Satellite); and the ERSDAC (Earth Remote Sensing Data Application Center).

The **MOS-1 (Marine Observation Satellite)** was the first Japanese Earth Observation space system. Primed by Nippon Electric Corporation (NEC) for NASDA, development started in 1980, and successful launch was effected in early 1987.

The system's primary objective is the observation of the oceans for the purpose of uncovering oceanic phenomena from which to infer the location and richness of fishing grounds.

A secondary objective are land observations, for investigating mineral and fossil fuel resources, principally petroleum, and for performing general land surveys and inventories of crops.

A third objective is the collection of data on sea ice, snowfall and water vapor content at the ocean surface and in the atmosphere—for purposes of eventually improving weather forecasts, principally for ships at sea.

MOS-1 is not a very advanced spacecraft. The sensors are:

- o The Multispectral Electronic Scanning Radiometer (MESSR), with a ground resolution of 50 meters in four visible and near-IR spectral bands (0.51 to 1.1 microns). The MESSR is essentially an adaptation of NASA's CCD (Charge Coupled Detector) sensors;

- o A Visible and Thermal Infrared Radiometer (VTIR), with resolution of 900 meters in the visible, 2,700 in the Infrared, and using three spectral bands. This is an adaptation of sensors that have flown on NOAA's weather satellites;

- o The Microwave Scanning Radiometer (MSR), with resolution of 23 km in the 31 GHz band, 32 Km in the 24 GHz band. The MSR was adapted from US instrumentation, although Nippon Electric (NEC) has been active in the development of microwave radiometers since the late fifties.

Thus far, Japan has received about 130 requests to use the MOS-1 data, 16 of which were foreign. Not a very large volume compared to the 1972-76 requests for NASA's ERTS program (well over 1,000), but still encouraging.

MITI's input to the MOS system consisted essentially in fostering the development of the **sensors**, in order to stimulate Japanese industry to "come up to par" with US technology. MITI's idea was the eventual sale of sensors to the world market—as well as producing them domestically to avoid their costly purchase abroad.

The **ERS-1 (Earth Resources Satellite**, also known as JERS-1, Japan Earth Resources Satellite), is much more sophisticated than MOS. Its primary objective is the search for deposits of petroleum. The second objective is the location of minerals. The primary sensor is a Synthetic Aperture Radar (SAR).

In MITI's thinking, the ERS-1 program will accomplish two things:

1. It will enable Japanese industry to come up to par with US industry in SAR technology. This will serve eventually to penetrate the US and European markets for sophisticated radar systems.

2. It will provide useful information that can serve two purposes:

i) Assist the Japanese oil industry in locating more and better petroleum and mineral deposits in areas where the industry already has concessions (we note in passing that several concessions to the Japanese are now in existence within the US).

ii) Form the basis for obtaining new concessions in Third World countries, principally in the Pacific basin, by trading SAR findings for exploration concessions. MITI's expectation is that concessions will be easier to obtain if Japan can show that it has sophisticated exploration tools that can speed up the search for productive areas, to the benefit of both grantor and grantee of the concession.

To achieve these objectives, ERS-1 is equipped with the following two classes of principal sensors:

1. A SAR with 25 to 30 meters ground resolution, operating at C-band, and capable of covering a swath 75 Km wide, under all weather conditions

2. A Visible and Near-Infrared Radiometer (VNIR), with a ground resolution of 25 to 30 meters, operating in four bands in the 0.45 to 0.95 micron spectral range; and covering a swath of about 100 Km.

The Orbit will be circular, sun-synchronous, 570 Km high.

The planning for ERS-1 began in 1981 as part of NASDA's program.

Launch date is planned for 1991-92, by an H-1 launcher from Tanegashima.

Intimate participants in the planning phase were the Japanese oil industry and MITI. MITI has had a dominant input, particularly in the choice of the sensors and of their specifications. The actual development of the system falls under NASDA.

MITI's thinking and dominance is illustrated by the fact that during the planning phase of ERS-1, several Japanese and foreign consultants recommended against use of the SAR, on the grounds of high cost, small improvement over optical sensors, and **no need** to achieve **all-weather** operation. This is because petroleum and mineral deposits do not exhibit dynamic changes as is the case for crops—thus if clouds obscure one scene, wait for the next one.

MITI, after listening attentively to all inputs, overrode this advice in favor of the objective of gaining know-how of SAR technology on the part of the Japanese industry.

The **Earth Resources Data Analysis Center (ERSDAC)** is a ground-based establishment specifically devoted to the processing and distribution of ERS-1 products, as well as to the investigation of promising petroleum and mineral deposits. Created in 1982, ERSDAC's funding derives from the Japanese oil industry and from MITI. Headquartered in Tokyo, ERSDAC is equipped with the best image-interpretation technologies now available, including a mainframe Fujitsu computer (a copy of the IBM series 4000, built in Japan under license), multicolor high resolution recorders, and study quarters for about 30 to 40 persons. ERSDAC is manned by petroleum and mineral geologists, plus data processing personnel.

Interpretations of ERS-1 data will be integrated by ERSDAC with all other available remotely sensed data: from MOS, SPOT, LANDSAT, and aircraft.

3.4.2 Microgravity

MITI has evidenced a strong interest in microgravity, in the belief that this technology can uncover important new products and processess for Japanese industry, both for the internal Japanese market and for export. The principal product and process areas in which MITI and Japanese industry have expressed interest thus far are:

- o Glass and glass derivatives—for improving the performance and lowering costs of optical systems such as cameras, projectors, robotic vision devices

- o Fiber optics strands—to improve the performance of fiber optic communications systems. Principal properties sought are reduced transmission loss (goal is 0.001 db/km), larger usable bandwidth (goal is 2,000 MHz or better), greater dynamic range (goal is at least 30 db)

- o Flexible, controllable light reflecting membranes obtained at low cost—for use in high-quality optical and electro-optical systems, such as self-focusing videocameras--and for attaining low-cost processes for producing high-quality aspherical lenses and/or reflectors

- o Materials for lasers--such as crystals and dopants, to enable the production of economical industrial laser devices

- o Semiconductor materials, with particular emphasis on: i) low-work function, efficient photoconverters (solar cells); ii) high transconductance (high mobility) microelectronic devices

- o Organic crystals, to explore their potential in the electronic and biological industries

Japan's private industry is significantly involved in microgravity planning. As indicated previously in this report, thirteen companies have formed the Institute for an **Unmanned Space Experiments Platform**, a major object of which is the definition of which areas of microgravity experimentation would yield the most effective, saleable, and economically producible products.

The Japanese have experimented with short duration ballistic rockets with limited results. Advanced plans are being developed for exploiting the opportunities offered by NASA's Space Station for microgravity research, at low cost to the Japanese.

3.4.3 Launch Vehicles

Launch vehicles have historically represented the earliest Japanese development in space technology. Beginning in the 1950's with the Kappa series, developments have progressed through the Lambda, Mu, and Nu series, all designed and built at the University of Tokyo, within the department that later became ISAS, led by Professor Itokawa. Since these small launch vehicles were intended strictly for scientific satellite purposes, their early development phases involved no interest on the part of MITI. Their role in space commercialization has been negligible.

Over the last five years, three main factors have awakened MITI's attention as regards commercial potential of launch vehicles: i) the examples of US ELV's and Ariane in launching commercial satellite payloads for a price; ii) the established world-wide market for telecommunications satellites; and iii) the growing capability and improving price/performance of Japanese launch vehicles.

US aerospace publications herald the near-term entry of Japan into the launcher business. In reality, MITI is currently pondering the advisability of introducing Japanese launchers on the commercial market.

In this respect, MITI's basic questions are twofold:

i) whether the volume of business, and the corresponding revenues, are sufficiently high to make the enterprise worthwhile from the standpoint of the Japanese economy, especially in view of the already entrenched competition. Prestige is not an issue with MITI

ii) whether such an enterprise should not rather be left at the discretion of Japanese private industry to pursue, if they so wish

Note that the capturing of foreign exchange, critical to PRC and USSR, is not significant to MITI nor is the aspect of National prestige, that motivates the Europeans to push Ariane (even though the revenues are a "drop in the bucket" with respect to Europe's economic needs). Both are but minor considerations in MITI's hard-headed business attitude.

Because of the above considerations, we cannot be sure at this time whether the Japanese will mount a concerted effort to commercialize their H-series launch vehicle. The absence of such an effort would not however exclude the Japanese selling launchers to anybody willing to purchase them; nor would it prohibit the Japanese entertaining joint ventures with foreign firms, where the Japanese could supply the vehicle, the other partner the launch services.

3.4.4 Communications

The commercial telecommunications satellite market has thus far been dominated by US manufacturers. MITI has not attempted to develop and market a commercial Japanese version.

As a matter of fact, as shown in Chart 21, most Japanese telecommunications satellites have been experimental: only the YURI 2A has truly commercial applications, for TV broadcast to Japan's interior.

Recent analyses by MITI indicate that the use of telecommunications satellites for telephone service inside Japan may not represent a very worthwhile venture when compared to employing the corresponding capital in widening the capacity of terrestrial systems. The analyses indicates that this somewhat pessimistic conclusion is due in part to the limited size of the Japanese territory (communications satellites begin breaking even economically with respect to terrestrial systems above a certain distance); and in part to the availability of new technologies, principally that of fiber optics transmission.

As a result, MITI has recommended to the Japanese government placing a moratorium on further plans to launch telecommunications satellites for domestic use. We note in passing that similar conclusions were drawn for Europe by analogous studies performed by American and European consultants. In Europe however, the drive for prestige overwhelms purely economic considerations.

The foregoing indicates that a future entry to the space telecommunications market on the part of Japan lies, if anything, still quite a bit in the future.

3.5 Long Range Planned Activities and Intent

The officially proposed Japanese space endeavors for the next decade and somewhat beyond are numerous. They include the development of a manned mini-shuttle; of manned voyages to Mars; of Japan's own space station. No plans or proposals have been disclosed for the commercial exploitation of space.

We attribute this ,in part, to the official postures of NASDA and ISIS, of disinterest in space commercialization; and, in part, to the fact that MITI and its industrial councils are still pondering precisely what to do to make the industrial use of space a truly profitable venture, one whose products can redund to the advantage of the Japanese economy and, hopefully, will also be exportable.

Looking back, however, and based on several discussions with MITI executives, we can discern two consistent trends: the first is the exploitation of the ERS-1 remote sensing satellite and the ERSDAC Data Center in the quest for petroleum and mineral concessions; the second is a cautious betting on the promise of microgravity. As regards the latter, we believe that MITI will carefully watch foreign results, embark on a relatively modest program of Japanese experimentation and jump in strongly as soon as the appearance of tangible results will demonstrate that the program is economically worthwhile.

CHART 17

RATES OF EXCHANGE BETWEEN

U.S. AND JAPAN

VALUE OF $1.00 IN TERMS OF

YEN AND OF ACCOUNTING UNITS

YEAR	RATES OF EXCHANGE	
	Official	PPP
1980	227	246
1981	221	236
1982	249	226
1983	238	220
1984	237	217
1985	238	—
1986	185	—
1987	152	—

Notes: — = not yet officially available.

CHART 18

COMPARISON BETWEEN TOTAL US AND TOTAL JAPANESE SPACE EXPENDITURES

CURRENT DOLLARS AND CURRENT AU'S

	TOTAL US (1)	TOTAL JAPAN		
	CIVIL & MILITARY	AT EXCHANGE RATES (2)		IN AU's
YEAR	$MILLION	$MILLION	% (3)	$AU MILLION
1980	7,668	467	6	350
1981	9,165	490	5.3	343
1982	11,860	498	4.2	463
1983	15,321	461	3	470
1984	17,060	479	2.8	537
1985	20,368	463	2.3	635
1986	22,091	500	2.3	685
1987	23,550	522	2.2	715

(1) "Total US" includes civilian (NASDA, NOAA, DOE) and space programs.

(2) Dollar-to-AU equivalent rates of exchange for each year shown.

(3) Total Japanese space expenditures as a percent of total US space expenditures.

CHART 19

COMPARISON BETWEEN NASA'S AND ESA'S EXPENDITURES AND TOTAL JAPANESE SPACE EXPENDITURES

CURRENT DOLLARS AT DOLLAR-AU EXCHANGE

	TOTAL JAPAN				
	NASA	ESA		% OF	% OF
YEAR	$MILLION	$MILLION	$MILLION	NASA	ESA
1980	4,340	800	467	10.8	58
1981	4,877	861	490	5.8	57
1982	5,453	724	498	9.1	69
1983	6,146	735	461	6.9	64
1984	6,385	804	479	7.5	50
1985	7,500	693	463	6.1	67
1986	7,764	998	500	6.4	50
1987	8,400	1,070	522	6.2	49

1987 Figures are budgeted expenditures

CHART 20

DISTRIBUTION OF NASDA'S EXPENDITURES

1986 (1)

Administration	12.7%
Launch Vehicle Development	35.5%
Satellite Development	28.5%
Launch Operations	7.4%
Launch Facilities	5 %
Tracking and Control	9.3%
Earth Observation Data Management	1.6%
TOTAL	100%

Total Expenditures: 645 MAU = $ 470 Million

(1) Additional space expenditures by ISAS and MITI combined amounted in 1986 to approximately 30 million.

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OF POOR QUALITY

CHART 21

JAPANESE COMMUNICATIONS SATELLITES

NAME	PRINCIPAL PURPOSE	LAUNCH DATE	AGENCY	PRIME CONTRACTOR
KIKU-2	Develop Technology of GEO insertion, tracking and control. Test transmissions at 1.7 GHz, 11.5 GHz, 34.5 GHz	1977	NASDA	Mitsubishi
SAKURA/CS	Test digital coding Time multiplexing technologies measure performance at 20-30 GHz, 14-12 GHz	1977	NASDA	Mitsubishi
SAKURA-2a	Similar to above	1983	NASDA	Mitsubishi
SAKURA-2b	Similar to above	1983	NASDA	Mitsubishi
YURI/BSE	Measure and Test performance of TV broadcast	1978	NASDA	Toshiba
AYAME/ECS	Test communications and orbit-keeping technologies. Failed at launch.	1979	NASDA	Mitsubishi
KIKU-3	Test of N-2 launcher; telecommunications gear	1981	NASDA	Mitsubishi
KIKU-4	Test of: 3-axis stabilization; solar panels; thermal control; communications gear	1982	NASDA	Mitsubishi

APPENDIX

SALIENT PHYSICAL CHARACTERISTICS

OF

PRINCIPAL EUROPEAN AND JAPANESE

COMMERCIALLY-ORIENTED SPACE SYSTEMS

This Appendix shows, for each spacecraft or launcher vehicle: size, weight, power, stabilization, design life.

For functional characteristics of the payloads and launch dates see Text.

TELECOMMUNICATIONS

ORBITAL TEST SATELLITE (OTS)

- Dimensions: Hexagonal prism, 2.39 m (7.84 ft) wide (max. circumscribed diameter), 2.13 m (7 ft) tall. Total length with solar panels extended: 9.26 m (30.38 ft)
- Weight in Orbit: 444 Kg (978.84 lbs)
- Power Supply: Solar, 594 watts
- Stabilization: 3 axes, gas propellant
- Design Service life: 5 years

MARITIME EUROPEAN COMMUNICATIONS SATELLITE (MARECS)

- Dimensions: Hexagonal Prism, 2 m (6.56 ft) wide (max. circumscribed diameter), 2.5 m (8.2 ft) tall. Total length with Solar Panels extended: 13.8 m (45.27 ft)
- Weight in Orbit: 563 Kg (1,241 lbs)
- Power Supply: Solar, 955 watts
- Stabilization: 3 axes, gas propellant
- Design Service Life: 7 years

EUROPEAN COMMUNICATIONS SATELLITE (ECS) SERIES (ECS -1,-2,-3,-4,-5)

- o Dimensions: Hexagonal prism, 2.18 m (7.15 ft) wide (max. circumscribed diameter), 2.4 m (7.8 ft) tall. Total length with solar panels extended: 13.8 m (45.27 ft)
- o Weight in Orbit: 700 Kg (1,543 lbs.)
- o Power Supply: Solar, 1,000 watts
- o Stabilization: 3 axes, gas propellant
- o Design Service Life: 7 years for ECS-1,-2,-3, up to 9 years for ECS-4 and ECS-5

OLYMPUS

- o Dimensions: Box shaped body, 2.1 m x 1.75 m (6.89 ft x 5.74 ft) wide, 3.5 m (11.48 ft) tall. Total length with solar panels extended: 27 m (88.58 ft)
- o Weight in Orbit: 2,422 Kg (5,340 lbs)
- o Power Supply: Solar, 3,300 watts
- o Stabilization: 3 axes, gas propellant
- o Design Service Life: 5 years

ADVANCED ORBITAL TEST SATELLITE (AOTS)

Still in early design phase, expected characteristics approximately those of Olympus

DATA RELAY SATELLITE (DRS)

Still in early design phase, expected characteristics approaching those of US TDRS.

LAND MOBILE COMMUNICATIONS SATELLITE (LMCS)

Still in the early planning phase. Current version is non cost-effective because of small antenna diameter (3 m) and limited number of channels (100 to 200). More capable version expected to be on the drawing board by 1988.

SPACE TRANSPORTATION

ARIANE 1 LAUNCH VEHICLE

- o Dimensions: 47.7 m (157.4 ft) high
- o Takeoff Weight at Liftoff: 210 tons (462,970 lbs)
- o Payload: 4,850 Kg (10,692 lbs) in 200 km, 5° inclimation LEO

  1,825 Kg (4,023 lbs) in geosynchronous transfer orbit (GTO)

  2,400 Kg (5,291 lbs) in polar sun-synchonous orbit (PSSO)

ARIANE 2 LAUNCH VEHICLE

o Intermediate between Ariane 1 and Ariane 3

ARIANE 3 LAUNCH VEHICLE

o Dimensions: 49 m (160.7 ft) high

o Takeoff weight at liftoff: 237 tons (522,496 lbs)

o Payload: 5,800 Kg (12,787 lbs) in 200km, 5° inclination LEO

2,390 Kg (5,269 lbs) in geosynchronous transfer orbit (GTO)

3,150 Kg (6,945 lbs) in polar sun-synchronous orbit (PSSO)

ARIANE 4

o Dimensions: 51 m (167.3 ft) high

o Takeoff weight at liftoff: 274 tons (602,800 lbs)

o Payload: 6,500 Kg (14,300 lbs) in 200 Km, 5° inclination LEO
2,900 Kg (6,380 lbs) in geosynchronous transfer orbit (GTO)
3,600 Kg (7,920 lbs) in polar sun-synchonous orbit (PSSO)

EARTH OBSERVATION

EUROPEAN REMOTE SENSING SATELLITE (ERS) SERIES

- o Dimensions: central section is a square prism, 2 m x 2 m (6.5 ft x 6.5 ft) on the side, 3.5 m (11.5 ft) tall. SAR, Total height including SAR antennas: 11.8 m (38.35 ft). Total length with solar panels extended: 11.7 m (38 ft). SAR antenna dimensions: 10 m (32.5 ft) long, 1 m (3.25 ft) wide
- o Weight in Polar Sun-synchronous Orbit: 2,160 Kg (4,752 lbs)
- o Power supply: Solar, variable power up to 2,600 watts max.
- o Stabilization: 3 axes, gas propellant
- o Design Service Life: 3 years

ADVANCED LAND APPLICATIONS SATELLITE (ALAS)

Still in the planning stage

METIEO P2

Anologous to the US GOES satellite

MICROGRAVITY

EURECA PLATFORM

- o Dimensions: Quadrangular box, 2.45 m, (8 ft) wide, 4 m (13.1 ft) tall, total length with solar panels extended: about 20 m (66 ft)

- o Weight in Orbit: 4,000 Kg (8,800 lbs). Weight of experimental payload: 1,000 Kg (2,200 lbs)

- o Power Supply: Solar, 5,400 watts

- o Other: Shuttle-compatible for deployment from and retrieval by Shuttle